

DISTRIBUTION PATTERNS, RELATIVE ABUNDANCE AND MANAGEMENT OF MAMMALS IN INDIRA GANDHI WILDLIFE SANCTUARY, TAMIL NADU, INDIA¹

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(With six text-figures)

Key words: Western Ghats, Anaimalai hills, Indira Gandhi Wildlife Sanctuary, vegetation types, mammals, distribution patterns, niche separation, management

The study reports the results from systematic sampling and 6 years of incidental encounters with wild mammals in Indira Gandhi Wildlife Sanctuary, Anaimalai hills in the Western Ghats, Tamil Nadu, India. A total of 239 plots were laid along 38 transects in different vegetation types, covering a length of 200 km. Data was collected during transect walks by direct sightings, whereas the plots were searched for the presence of signs and tracks. Gaur, sambar and muntjac occurred with a higher frequency in rainforest, while chital and pig did so in other vegetation types. Elephants moved in the dry season to the wet western ranges and back in the wet season to the dry eastern ranges. Tiger had a higher frequency in the wet forests, while that of leopard was higher in the drier forest types. The dry forests at lower altitudes were occupied by the common palm civet, while the forested areas of higher altitudes were largely inhabited by brown palm civet, along with the small Indian civet which occurred commonly in the open areas. Malabar giant squirrel had a relatively higher frequency in other vegetation types than in the riparian forests of the eastern ranges, which were inhabited by grizzled squirrel. The dry forests at lower altitudes were occupied by bonnet macaque and Hanuman langur, whereas the wet forests of the higher altitude were occupied by lion-tailed macaque and Nilgiri langur. The wet ranges in the Sanctuary were characterized by fragmentation of rainforest, and the dry ranges had high biotic pressure. The implications of the mammalian distribution pattern and other biotic factors for the management of these hills are discussed.

INTRODUCTION

In southern India, wildlife habitats include the coastal plains, the Western and the Eastern Ghats, the central plains of northern Karnataka and Andhra Pradesh, the Deccan plateau, and the central plains of Tamil Nadu. These habitats differ in altitude, rainfall, terrain, soil structure, temperature and other factors. Among these, the most biodiverse is the Western Ghats, one of the hot spots of biodiversity in the world.

The Western Ghats run parallel to the west coast. Topographically, they can be divided into three zones: (a) the flat and narrow coast, (b) the rising ridge, a high rainfall area with evergreen and semi-evergreen forests, and (c) the eastern zone, with low rainfall, characterized primarily by scrub or deciduous forests. Kumar (1997) reports that of the nearly 15,000 species of flowering plants in India, 30 per cent occur in the Western Ghats, of which about 1,200 are endemic; of 158 species of fish in the Western Ghats, about 50 are endemic; of the 120 species of amphibians (total 205 in India), 90 are endemic; all of the 33 species of Uropeltids and 7 pit vipers of the Western Ghats are endemic (Inger and Dutta 1986); of about 500 species of birds, 15 are endemic (Daniels 1994). A large number of mammals, including the lion-tailed

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macaque (*Macaca silenus*), Nilgiri langur (*Presbytis johnii*), Nilgiri tahr (*Hemitragus hylocrius*), Malabar civet (*Viverra megaspila*), Malabar spiny dormouse (*Platacanthomys lasiurus*), Nilgiri marten (*Martes gwatkinsi*), Brown palm civet (*Paradoxurus jerdoni*), are endemic to the Western Ghats. Because of the uniqueness of this habitat, several areas in the Western Ghats have been brought under the 'Protected Area Network'. Johnsingh (1986) reported that of the total 78,387 sq. km area of the Western Ghats, 17,613 sq. km was brought under National Parks and Wildlife Sanctuaries. Some of the most important protected areas in the Western Ghats include Sharavathi Hills, Kudremukh National Park, Pushpagiri Wildlife Sanctuary, Brahmagiri Wildlife Sanctuary, Silent Valley National Park, Indira Gandhi Wildlife Sanctuary, Periyar Wildlife Sanctuary and Kalakad-Mundanthurai Tiger Reserve. Karanth (1992) has discussed in detail the factors that caused, and continue to cause, serious deterioration of forests in the Western Ghats in Karnataka. The same factors also explain the habitat deterioration in the states of Tamil Nadu and Kerala. They include the disturbance caused by human settlements, developmental projects, collection of forest produce, and hunting. The low lying areas of the Western Ghats were clear felled for rice and plantation crops, and the middle ranges were cleared for coffee and tea plantations. These agricultural activities also brought permanent settlers who required roads, bridges, electricity, schools and, hospitals. Since the Western Ghats receive high rainfall, the region has also become important for the construction of large and medium dams for power generation and irrigation. The forest produce collected from the Western Ghats includes cane, reeds, fruits and softwood for matchwood and plywood. Since all the above factors resulted in increased human activity, these may also have increased hunting in the region.

Indira Gandhi Wildlife Sanctuary

(previously Anaimalai Wildlife Sanctuary) is one of the important ecoregions of the Western Ghats. Extensive research has been taken up on non-human primates in this Sanctuary (Kumar 1987, Menon and Poirier 1996, Singh *et al.* 1997a & b, 1998, 2000, Kumara *et al.* 2000a, Kumar *et al.* 2001). The effect of rainforest fragmentation on arboreal and terrestrial mammals has been reported by Kumar *et al.* (1995, 1998). Davidar (1978), and Mishra and Johnsingh (1998), undertook a thorough survey on the Nilgiri tahr in the Sanctuary. The above mentioned studies concentrated on particular species of mammals. There has been no study to document the overall distribution pattern of mammals, their occurrence in specific habitats, community structure and habitat preferences in the Sanctuary. The annual wildlife censuses carried out by the Forest Department, deal only with the animals sighted. They do not provide an assessment of habitats, or other conservation and management related issues. In this context, the present study was undertaken from June 1999 to July 2000.

OBJECTIVES

1. To document the distribution patterns and abundance of mammals in the various habitat types in the Sanctuary.
2. To document the presence of biotic pressures in different areas, and to assess whether these pressures have an impact on the occurrence of wild mammals.
3. To assess the effect of physical factors, including natural and man-made barriers, on the movement of large mammals.

Because of methodological problems, bats and terrestrial rodents were not included in this study.

STUDY AREA

Anaimalai Ecosystem and Indira Gandhi Wildlife Sanctuary: Nearly 2,000 sq.

km of Anaimalai ecosystem includes the present Indira Gandhi Wildlife Sanctuary (Tamil Nadu), Parambikulam Wildlife Sanctuary (Kerala), Nelliampathy Hills (Kerala), parts of Palni Hills (Tamil Nadu) and, the Chinnar and Eravikulam Wildlife Sanctuaries (Kerala). These hills occupy a unique place in the Western Ghats, since the Ghats are widest (east to west) at this point. The present Indira Gandhi Wildlife Sanctuary and National Park is located at $10^{\circ} 13' 08''$ to $10^{\circ} 33' 27''$ N, and $76^{\circ} 49' 02''$ to $77^{\circ} 21' 07''$ E. In 1976, it was declared a Sanctuary encompassing 958 sq. km. In 1989, 108 sq. km of this Sanctuary was declared a National Park, which included Karian Shola, Grasshills and Manjampatty. The entire Sanctuary lies in the Western Ghats. It includes the low lying northern and eastern plains, two plateaus, and the high hills. The altitude ranges from about 275 m above msl in the Amaravathi Range and about 340 m above msl in the Pollachi Range, to nearly 2,500 m above msl in the Valparai Range. The rainfall varies from an annual average of 50 cm in the eastern side of the Sanctuary to about 500 cm in the western plateaus and slopes. The Sanctuary receives both southwest and northeast monsoon. However, the former is predominant in the western region and the latter in the eastern region.

Anaimalai Hills have a long history of forestry and related operations (Davidar 1987). Most of the area is characterized by steep hills and deep valleys. However, there are two large plateaus at Top Slip and Valparai. About 150 years back, these hills contained undisturbed and contiguous tracts of forests. The two plateau regions first came under horticulture and forestry.

a. Teak Plantations in Top Slip Plateau: Because of the medium elevation (< 700 m above msl) and medium rainfall (150 cm), this plateau primarily contained moist deciduous forests dominated by bamboo and teak. Vast stretches were opened up for teak plantations (Sundararaju 1987). Only a few stretches of mixed deciduous

and bamboo forest were left, which have been serving as a crucial habitat for certain animals.

b. Tea Plantations in Valparai Plateau: Because of the higher elevation ($> 1,000$ m above msl) and relatively higher rainfall (> 250 cm), this plateau contained rainforests and semi-evergreen forests. The region was found highly suitable for growing tea and coffee (Congreve 1938). More than 20,000 ha of these forests around the present town of Valparai were leased to private companies, clear felled and converted into tea gardens, which brought a large number of people from the plains to the hills, where they became permanent settlers (now $< 200,000$).

c. Hydel projects: The third onslaught disturbing wildlife habitats critically is from the water harvesting schemes in this hill system. Although these hills receive high rainfall, the plains on the eastern side are very dry. It was realized that dams could be constructed at various places and the deep valleys would store an enormous amount of water for irrigation and power generation. Four water management schemes were, therefore, taken up in these hills. The Sholaiyar system includes smaller dams up hills such as Nirar, and larger dams including Sholaiyar, Parambikulam and Thunakadavu downstream. The second scheme includes the Kadamparai dam, Upper Aliyar and Lower Aliyar dams. On the eastern side, the two single dam schemes include Tirumurthy and Amaravathi. Power generation was taken up at Sholaiyar, Kadamparai, Navamalai and Sarkarpathi. A 49 km long contour canal was built to divert the Thunakadavu-Parambikulam water from the west to drain into Tirumurthy on the east.

In spite of these onslaughts on the forests, the Anaimalai Hills still retain some of the finest wildlife habitats in southern India. The hills are characterized by diverse forest types (Fig. 1). The lower elevation areas around Navamalai in Pollachi Range, and the areas of Amaravathi and Udumalpet ranges contain southern tropical

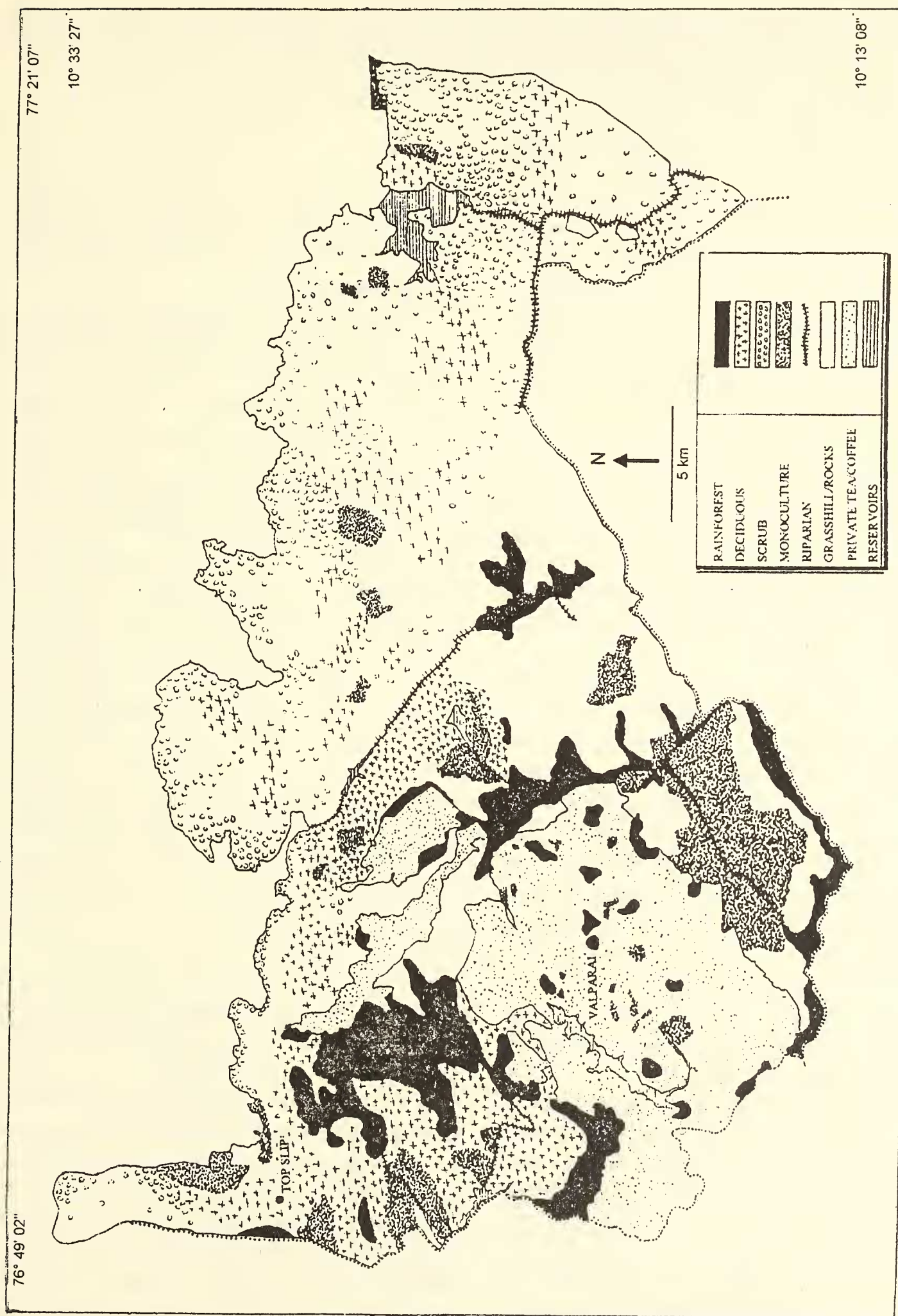


Fig. 1: Major vegetation types in Indira Gandhi Wildlife Sanctuary

thorn forests. The medium altitude ranges around Attakatti, Upper Aliyar, Kadamparai region and Top Slip region are characterized by deciduous forests. The upper ranges (>1,000 m above msl) around Valparai and even the middle elevation but high rainfall areas of Vargaliar-Panathiar region harbour rainforests. The mountain slopes (>1,800 m above msl) support typical shola forests, whereas the mountain tops are characterized by extensive stretches of grasslands, making it a typical montane habitat. Kumar *et al.* (1998) characterize the tropical wet evergreen forests in Indira Gandhi Wildlife Sanctuary as dominated by *Cullenia-Mesua-Palaquium*, *Hopea-Mesua-Artocarpus* and *Dipterocarpus-Anacolosia* associations; tropical montane forests dominated by *Gordonia-Michelia-Eugenia* species; mixed dry and moist deciduous forests dominated by *Tectona-Terminalia-Dillenia-Lagerstroemia* species; and thorn forests by several species of *Acacia*, *Zizyphus* and *Albizzia*.

This variety of habitats accounts for the diverse wildlife in the hills. The scrub and deciduous forests are home to most of the terrestrial mammals. The rainforests support a large variety of arboreal wildlife, and the peaks harbour typical montane species such as Nilgiri tahr. However, wildlife management in the Anaimalai Hills is a serious challenge. In addition to the past pressures, the present day problems include:

a. The management of wildlife in fragmented forests, especially in the rainforest fragments, and areas around the 35 tribal settlements in the Sanctuary.

b. The management of people: The tribes on the western side live primarily in rainforests and generally do not maintain livestock, while those settled in the dry forests on the eastern side maintain large stocks of cattle. Therefore, the grazing pressure is high on the eastern side. Similar biotic pressure is also faced from the villages outside the Sanctuary limits on the

northern and eastern sides. Apart from the pressure of grazing by livestock, human pressures also visibly affect the Valparai plateau.

METHODS

The two methods used were systematic sampling and incidental encounters. Systematic sampling was carried out by the line transect method and plot method.

Line Transect Method: Transects of varying length were laid in different habitat types (Fig. 2). The length of each transect was measured using a pedometer. All transects were not straight lines, due to the mountainous terrain and presence of several water reservoirs. Table 1 provides a summary of the length of transects in different forest ranges and vegetation types. A total of 38 transects were laid, covering a length of 200.47 km. A single transect could run through more than one vegetation type. All transects were walked at least once and most of them were repeated in wet and dry seasons. While walking a transect, the season, transect number, transect length, length of each vegetation type along a transect, mammalian species encountered, number of animals of each species sighted, distance of each animal from the starting point of the transect, and altitude were recorded. The data collected through this method were used for estimating encounter rates of various mammalian species. To some extent, this estimate was influenced by differences in visibility among various vegetation types. In the text, monoculture refers to teak and eucalyptus plantations inside the Sanctuary.

Plot Method: This was the second method employed in systematic sampling. Each plot was 3 m in width and 50 m in length. A plot was laid at every 500 m along the transect lines. The details of these plots are provided in Table 1. The plots were investigated only once, when information was recorded on season, vegetation type, signs of mammalian species (sightings,

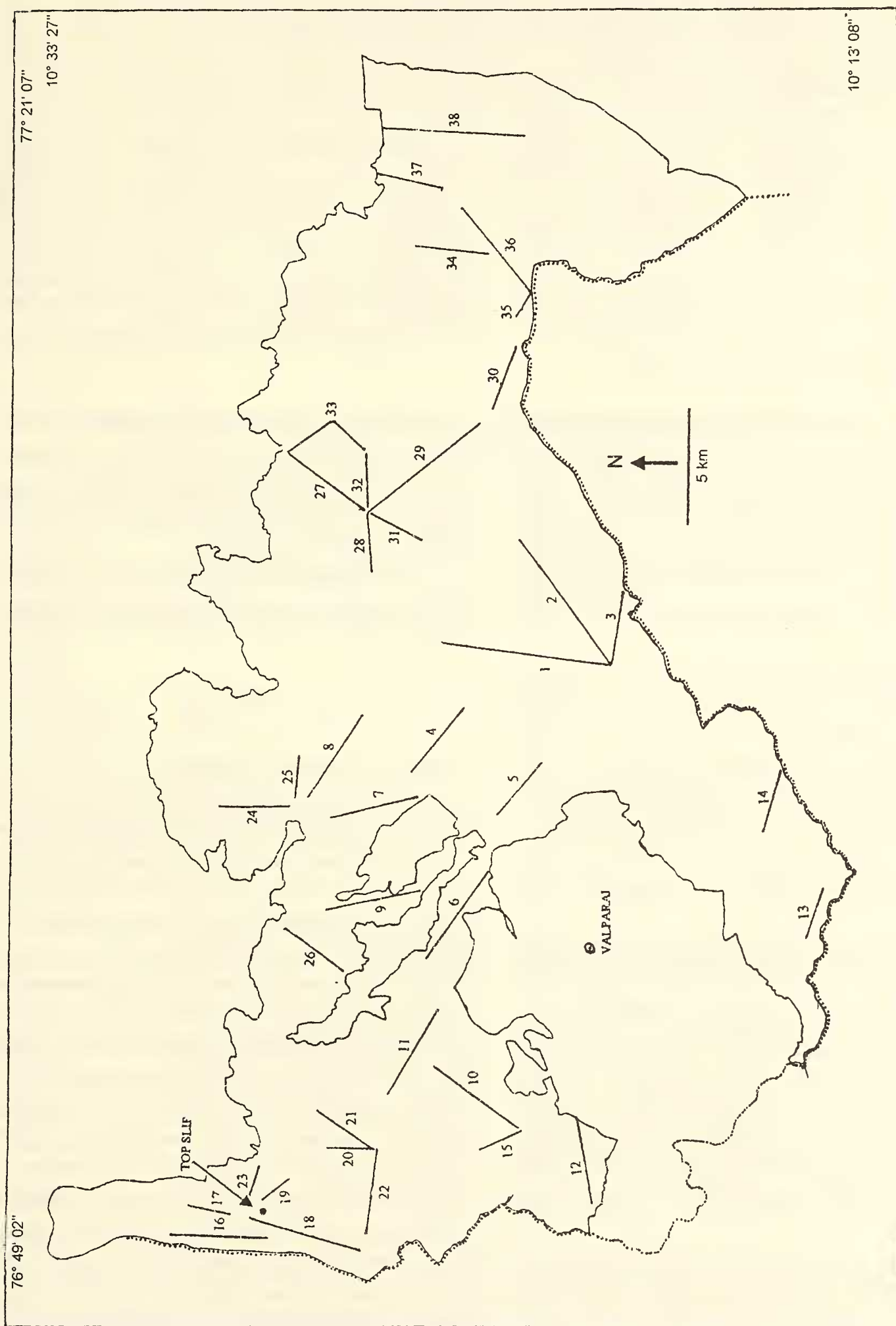


Fig. 2: Locations of line transects during the survey in Indira Gandhi Wildlife Sanctuary
(see Appendix-II for names of places and distance of transects)

TABLE 1
DISTANCE COVERED (M) IN LINE TRANSECTS AND NUMBER OF PLOTS
IN VARIOUS RANGES AND FOREST TYPES

Range	Rainforest	Deciduous	Riparian	Scrub	Grassland	Monoculture	Total
Valparai	27,900 (27)	9,650 (13)	3,900 (7)	1,750 (4)	10,800 (15)	1,700 (4)	55,700 (70)
Manampalli	27,434 (29)	11,176 (8)	2,400 (3)	330 (1)	-	1,200 (1)	42,540 (42)
Ulandy	8,467 (9)	7,490 (13)	-	1,700 (1)	-	4,218 (7)	21,875 (30)
Pollachi	1,640 (1)	3,260 (7)	2,000 (2)	4,000 (4)	-	-	10,900 (14)
Udumalpet	2,930 (4)	2,903 (5)	14,413 (13)	29,522 (43)	4,532	842 (2)	55,142 (67)
Amaravathi	-	-	5,562 (7)	8,750 (9)	-	-	14,312 (16)
Total	68,371 (70)	34,479 (46)	28,275 (32)	46,052 (62)	15,332 (15)	7,960 (14)	2,00,469 (239)

Values in parentheses indicate number of plots

fresh signs of tracks, droppings, scrapes, feeding, digging, kills), altitude, dung deposits by livestock, woodcutting, poaching (snare, traps and encounters with poachers) and movement of people. Grazing was considered moderate if less than 60% plots per transect had cattle dung deposits, and severe if more than 60% had the same.

Woodcutting was also classified as rare or common, with similar percentage of plots per transect with stumps of cut wood. Average number of poaching signs per kilometre was calculated. The data collected through this method was used to record the absence or presence of wild mammals, as well as to assess the effect of biotic factors on occurrence of wild mammals.

Incidental Encounters (day and night):

A systematic record has been kept on all mammalian species sighted in different parts of the Indira Gandhi Wildlife Sanctuary since July 1994. We also made several night trips by jeep and on foot in a few accessible places, primarily in the deciduous and rainforest. Such data have been used to indicate the presence and relative encounter rates, especially of some small mammals.

Regular *ad libitum* notes on physical barriers, and movement of people in the forest were also maintained from the information

gathered from locals and forest staff. The data on the distribution of the Nilgiri tahr was collected through *ad libitum* sampling, since transect or plot method did not provide reliable information for this species.

Data analysis was carried out by applying the chi-square test for k proportions (Gibbons 1971).

RESULTS

Large Herbivorous Mammals

Occurrence in different vegetation types: Tables 2 and 3 present the data on encounter rates in transects and occurrence of signs in plots, respectively, on large herbivorous mammals in different vegetation types. The significance of difference for vegetation types was calculated through the chi-square test for k proportions for each species separately (Gibbons 1971). Except for muntjac (*Muntiacus muntjak*), the encounter rates of all animals differed significantly among various vegetation types (Table 2). In plots too, except for sambar (*Cervus unicolor*), and wild pig (*Sus scrofa*), the percent of occurrence of signs differed significantly among different vegetation types (Table 3). The direct sighting data reveal that these mammalian species occur with a higher frequency in relatively drier forests including monoculture. On the other hand, the

plot data shows more signs of these species in the rainforest, riparian forest and monoculture. Chital (*Axis axis*) was found to occur primarily in the scrub forest, with the exception of a small population in a deciduous forest at Top Slip. Contingency coefficient was also calculated for gaur (*Bos gaurus*), sambar, muntjac, chital and wild pig for their occurrence in rainforest and other vegetation types (combined) for the data presented in Table 3. A significant chi-square ($\chi^2=20.99$; $df=4$; $p=0.01$) revealed that, whereas gaur, sambar and muntjac had a higher frequency

in rainforest, chital and wild pig had a higher frequency in other vegetation types.

Occurrence at different altitudes: Tables 4 and 5 present data on large herbivorous mammals at different altitudes. Except for muntjac, the encounter rates differed significantly in relation to altitude (Table 4), whereas sambar, chital and wild pig were sighted with a higher frequency at <500 m, elephant (*Elephas maximus*) and gaur were encountered more frequently at 500-1,500 m. However, the plot data (Table 5) revealed no significant

TABLE 2
NUMBER OF LARGE HERBIVOROUS MAMMALS ENCOUNTERED IN DIFFERENT VEGETATION TYPES
IN INDIRA GANDHI WILDLIFE SANCTUARY

Species	Rainforest	Deciduous	Riparian	Scrub	Grassland	Monoculture	Chi-square	p
Elephant	11 (0.16)	10 (0.29)	8 (0.28)	1 (0.02)	-	1 (0.13)	17.5	.01
Gaur	23 (0.34)	16 (0.46)	2 (0.04)	12 (0.26)	17 (1.11)	13 (1.63)	99.5	.01
Sambar	5 (0.07)	11 (0.32)	6 (0.10)	25 (0.54)	-	-	42.9	.01
Muntjac	9 (0.13)	5 (0.15)	2 (0.04)	1 (0.02)	-	1 (0.13)	7.1	NS
Chital	-	-	-	52 (1.13)	-	-	235.4	.01
Wild pig	-	-	8 (0.14)	29 (0.62)	-	-	91.0	.01
Total distance of transects (km)	68.37	34.48	28.28	46.05	15.33	7.96		
Animal/km	0.70	1.22	0.92	2.61	1.1	1.88		

Elephant (*Elephas maximus*); Gaur (*Bos gaurus*); Sambar (*Cervus unicolor*); Muntjac (*Muntiacus muntjak*); Chital (*Axis axis*); Wild pig (*Sus scrofa*).

Values in parentheses indicate encounter rate per kilometre

TABLE 3
OCCURRENCE OF SIGNS OF LARGE HERBIVOROUS MAMMALS IN PLOTS
IN DIFFERENT VEGETATION TYPES IN INDIRA GANDHI WILDLIFE SANCTUARY

Species	Rainforest	Deciduous	Riparian	Scrub	Grassland	Monoculture	Chi-square	p
Elephant	21 (30.0)	22 (47.8)	19 (59.4)	26 (41.9)	4 (26.6)	8 (57.1)	11.5	.05
Gaur	33 (47.1)	12 (26.1)	6 (18.7)	4 (6.4)	6 (40.0)	7 (50.0)	32.5	.01
Sambar	39 (55.7)	17 (36.9)	14 (43.7)	23 (37.1)	1 (6.6)	5 (35.7)	6.5	NS
Muntjac	16 (22.8)	8 (17.4)	5 (15.6)	2 (3.2)	-	2 (14.3)	13.6	.05
Chital	-	2 (4.3)	3 (9.4)	10 (16.1)	-	1 (7.1)	15.7	.01
Wild pig	5 (7.1)	3 (6.5)	3 (9.4)	9 (14.5)	-	3 (21.4)	6.5	NS
Number of Plots	70	46	32	62	15	14		
Signs/plot	1.63	1.39	1.56	1.19	0.73	1.86		

Values in parentheses indicate occurrence of signs in per cent plots

TABLE 4
NUMBER OF LARGE HERBIVOROUS MAMMALS ENCOUNTERED AT DIFFERENT ALTITUDES (M)
IN INDIRA GANDHI WILDLIFE SANCTUARY

Species	<500	501-1000	1001-1500	>1500	Chi-square	p
Elephant	3 (0.09)	24 (0.22)	4 (0.10)	-	9.1	.05
Gaur	-	37 (0.34)	23 (0.55)	17 (0.28)	49.9	.01
Sambar	26 (0.80)	8 (0.07)	10 (0.24)	-	83.8	.01
Muntjac	1 (0.03)	13 (0.12)	2 (0.05)	-	5.5	NS
Chital	51 (1.57)	-	-	-	357.9	.01
Wild pig	33 (1.02)	4 (0.04)	-	-	180.4	.01
Total distance of Transects (km)	32.51	108.22	41.51	18.24		
Animals/km	3.51	0.79	0.94	0.93		

Values in parentheses indicate encounter rate per kilometre

TABLE 5
OCCURRENCE OF SIGNS OF LARGE HERBIVOROUS MAMMALS IN PLOTS
AT DIFFERENT ALTITUDES (M) IN INDIRA GANDHI WILDLIFE SANCTUARY

Species	<500	501-1000	1001-1500	>1500	Chi-square	p
Elephant	17 (45.9)	49 (44.5)	21 (36.8)	13 (37.1)	1.5	NS
Gaur	5 (13.5)	38 (34.5)	11 (19.3)	14 (40.0)	10.7	.05
Sambar	20 (54.1)	46 (41.8)	24 (42.1)	9 (25.7)	6.0	NS
Muntjac	3 (8.1)	15 (13.6)	12 (21.0)	3 (8.6)	4.3	NS
Chital	13 (35.1)	3 (2.7)	-	-	57.3	0.1
Wild pig	6 (16.2)	15 (13.6)	2 (3.5)	-	10.1	.05
Number of Plots	37	110	57	35		
Signs/plot	1.73	1.51	1.23	1.11		

Values in parentheses indicate occurrence of signs in per cent plots

difference in the distribution of elephant, sambar and muntjac with altitude. Chital and gaur occupied lower (<500 m) and higher (500-1,500 m) ranges respectively. Whereas the encounter data revealed significantly higher overall frequency of these species at <500 m (Table 4), this difference was not significant in the plots data (Table 5).

Large Carnivorous Mammals

Occurrence in different vegetation types and at different altitudes: Tables 6 and 7 present the data collected through plot method on large carnivorous mammals in relation to vegetation types and altitude respectively. Significant differences in the occurrence in relation to vegetation type and altitude were found only for

bear (*Melursus ursinus*) and leopard (*Panthera pardus*). Bear occurred with a higher frequency in deciduous, riparian, scrub and monoculture forests, as against rainforest and grasslands (Table 6). The occurrence of leopard was greater in riparian, scrub and grassland and monoculture regions as compared to rainforest and deciduous forest. The overall occurrence of large carnivores was greater in scrub and monoculture areas. Whereas bear had a higher frequency at >500 m (Table 7), the leopard was abundant at <1,000 m. Contingency coefficient was also calculated for occurrence of leopard and tiger (*Panthera tigris*) in rainforest and other vegetation types (combined) for the data in Table 6. A significant chi-square ($\chi^2=4.97$; $df=1$; $p=0.05$) revealed that leopard and tiger occurred with higher

TABLE 6
OCCURRENCE OF SIGNS OF LARGE CARNIVOROUS MAMMALS IN PLOTS
IN DIFFERENT VEGETATION TYPES IN INDIRA GANDHI WILDLIFE SANCTUARY

Species	Rainforest	Deciduous	Riparian	Scrub	Grassland	Monoculture	Chi-square	p
Dhole	3 (4.3)	-	-	4 (6.4)	-	-	6.4	NS
Bear	4 (5.7)	12 (26.1)	5 (15.6)	13 (21.0)	-	3 (21.4)	13.6	.05
Leopard	4 (5.7)	1 (2.2)	3 (9.4)	7 (11.3)	2 (13.3)	5 (35.7)	16.1	.01
Tiger	6 (8.6)	2 (4.3)	1 (3.1)	-	-	1 (7.1)	7.1	NS
Jackal	-	-	-	1 (1.6)	-	-	2.9	NS
Number of Plots	70	46	32	62	15	14		
Signs/plot	0.24	0.33	0.28	0.40	0.13	0.64		

Dhole (*Cuon alpinus*); Bear (*Melursus ursinus*); Leopard (*Panthera pardus*); Tiger (*Panthera tigris*);

Jackal (*Canis aureus*)

Values in parentheses indicate occurrence of signs in per cent plots

TABLE 7
OCCURRENCE OF SIGNS OF LARGE CARNIVOROUS MAMMALS IN PLOTS
AT DIFFERENT ALTITUDES (M) IN INDIRA GANDHI WILDLIFE SANCTUARY

Species	<500	501-1000	1001-1500	>1500	Chi-square	p
Dhole	2 (5.4)*	4 (3.6)	-	1 (2.9)	2.7	NS
Bear	2 (5.4)	27 (24.5)	8 (14.0)	-	16.3	.01
Leopard	7 (18.9)	12 (10.9)	1 (1.7)	2 (5.7)	8.9	.05
Tiger	1 (2.7)	6 (5.4)	1 (1.7)	2 (5.7)	1.7	NS
Jackal	-	1 (0.9)	-	-	1.2	NS
Number of Plots	37	110	57	35		
Signs/plot	0.32	0.45	0.18	0.14		

Values in parentheses indicate occurrence of signs in per cent plots

frequencies in other vegetation types and rainforest, respectively.

Small Mammals

Occurrence in different vegetation types: Tables 8 and 9 present the data on the occurrence of small mammals in different vegetation types. Mongoose and hare were encountered more in the drier forests than in the rainforest (Table 8). Whereas pangolin (*Manis crassicaudata*) and porcupine (*Hystrix indica*) were evenly distributed in all vegetation types (Table 9), mouse deer (*Tragulus meminna*) occurred with a higher frequency in rainforest and monoculture, and the small Indian civet (*Viverricula indica*) and brown palm civet were abundant in the

rainforest and grassland. A contingency coefficient analysis was applied to the occurrence of small mammals in rainforest and other vegetation types (combined) for the data in Table 9. A significant chi-square ($\chi^2=8.65$; $df=3$; $p=0.05$) revealed that mouse deer and civet occurred with a higher frequency in rainforest, while pangolin and porcupine had a higher frequency in other vegetation types.

Occurrence at different altitudes: Tables 10 and 11 present the data on the occurrence of small mammals at different altitudes. Only the hare had a significantly higher frequency at <1,000 m as against >1,000 m (Table 10). However, the data from plots gave non-significant difference in the occurrence of mouse

TABLE 8
NUMBER OF SMALL MAMMALS ENCOUNTERED IN DIFFERENT VEGETATION TYPES
IN INDIRA GANDHI WILDLIFE SANCTUARY

Species	Rainforest	Deciduous	Riparian	Scrub	Grassland	Monoculture	Chi-square	p
Mouse deer	1 (0.01)	1 (0.02)	-	-	-	1 (0.13)	8.4	NS
Mongoose	-	-	-	2 (0.04)	-	1 (0.13)	11.4	.05
Hare	-	2 (0.06)	-	5 (0.11)	-	-	12.3	.05
Total distance of transects (km)	68.37	34.48	28.28	46.05	15.33	7.96		
Animal/km	0.01	0.09	-	0.15	-	0.25		

Values in parentheses indicate encounter rate per kilometre

TABLE 9
OCCURRENCE OF SIGNS OF SMALL MAMMALS IN PLOTS IN DIFFERENT VEGETATION TYPES
IN INDIRA GANDHI WILDLIFE SANCTUARY

Species	Rainforest	Deciduous	Riparian	Scrub	Grassland	Monoculture	Chi-square	p
Mouse deer	8 (11.4)	2 (4.3)	-	-	-	1 (7.1)	12.9	.05
Civet	11 (15.7)	3 (6.5)	3 (9.4)	3 (4.8)	5 (33.3)	-	14.9	.05
Pangolin	2 (2.8)	4 (8.7)	-	-	-	1 (7.1)	9.5	NS
Porcupine	3 (4.3)	4 (8.7)	3 (9.4)	7 (11.3)	-	1 (7.1)	3.8	NS
Number of Plots	70	46	32	62	15	14		
Signs/plot	0.34	0.28	0.19	0.16	0.33	0.21		

Values in parentheses indicate occurrence of signs in per cent plots

deer, civet, pangolin and porcupine at different altitudes (Table 11).

Arboreal Mammals

Occurrence in different vegetation types and at different altitudes: Tables 12 and 13 present the data on the encounter rates of arboreal mammals in different vegetation types and altitudes. Significant differences were observed in the occurrence of all arboreal species inhabiting different vegetation types (Table 12). Malabar giant squirrel (*Ratufa indica*) had a higher frequency in rainforest, deciduous forest and monoculture; grizzled squirrel (*Ratufa macroura*) had a higher frequency in riparian forest; bonnet macaques (*Macaca radiata*) occurred only in deciduous and riparian forests; lion-tailed macaques had a higher frequency in the rainforest; Nilgiri langur in the rainforest and

deciduous forest; and Hanuman langur (*Presbytis entellus*) in riparian forest. Significant differences were observed for all arboreal mammals in their occurrence at different altitudes (Table 13). Whereas Malabar giant squirrel was encountered with a higher frequency at altitudes of >500 m, the grizzled squirrel was encountered at <500 m only. Bonnet macaque and Hanuman langur occurred primarily at <500 m, whereas lion-tailed macaque and Nilgiri langur occurred at >500 m.

Distribution of mammals in wet and dry ranges

In Indira Gandhi Wildlife Sanctuary, the western ranges receive higher rainfall (>250 cm) than the eastern ranges (<75 cm). The distribution pattern of a few important prey and predator species was analyzed by combining the

data from plots in different ranges. Whereas gaur and mouse deer had a significantly higher frequency in the wetter ranges, the dry ranges had a higher frequency of chital (Table 14). Although tiger occurred with a higher frequency in the wet ranges, and leopard and dhole (*Cuon alpinus*) occurred with a higher frequency in the dry ranges, the difference in their distribution failed to reach the statistical significance (Table 14).

TABLE 10
NUMBER OF SMALL MAMMALS ENCOUNTERED AT DIFFERENT ALTITUDES (M)
IN INDIRA GANDHI WILDLIFE SANCTUARY

Species	<500	501-1000	1001-1500	>1500	Chi-square	p
Mouse deer	-	3 (0.03)	-	-	2.6	NS
Mongoose	2 (0.06)	1 (0.01)	-	-	5.9	NS
Hare	4 (0.12)	3 (0.03)	-	-	9.9	.05
Total distance of Transects (m)	32,505	1,08,217	41,511	18,236		
Animal/km	0.18	0.06	-	-		

Values in parentheses indicate encounter rate per kilometre

TABLE 11
OCCURRENCE OF SIGNS OF SMALL MAMMALS IN PLOTS AT DIFFERENT ALTITUDES (M)
IN INDIRA GANDHI WILDLIFE SANCTUARY

Species	<500	501-1000	1001-1500	>1500	Chi-square	p
Mouse deer	-	7 (6.4)	3 (5.3)	1 (2.9)	2.9	NS
Civet	2 (5.4)	10 (9.1)	6 (10.5)	7 (20.0)	4.6	NS
Pangolin	1 (2.7)	3 (2.7)	3 (5.3)	-	2.2	NS
Porcupine	6 (16.2)	8 (7.3)	3 (5.3)	1 (2.3)	5.5	NS
Number of Plots	37	110	57	35		
Signs/plot	0.24	0.25	0.26	0.26		

Values in parentheses indicate occurrence of signs in per cent plots

TABLE 12
NUMBER OF ARBOREAL MAMMALS ENCOUNTERED IN DIFFERENT VEGETATION TYPES
IN INDIRA GANDHI WILDLIFE SANCTUARY

Species	Rainforest	Deciduous	Riparian	Scrub	Grassland	Monoculture	Chi-square	p
Giant squirrel	56 (0.82)	21 (0.61)	8 (0.14)	-	-	4 (0.50)	94.9	.01
Grizzled squirrel	-	-	6 (0.11)	-	-	-	37.7	.01
Bonnet macaque	13 (0.19)	136 (3.94)	69 (2.44)	25 (0.54)	-	-	1657.6	.01
Lion-tailed macaque	93 (1.36)	-	-	-	-	-	335.2	.01
Nilgiri langur	345 (5.05)	147 (4.26)	-	-	-	17 (2.14)	284.4	.01
Hanuman langur	-	19 (0.55)	97 (3.43)	30 (0.65)	-	-	1295.7	.01
Total distance of transects (km)	68.37	34.48	28.28	46.05	15.33	7.96		
Animal/km	7.41	9.37	6.37	1.19	-	2.64		

Giant squirrel (*Ratufa indica*); Grizzled squirrel (*Ratufa macroura*); Bonnet macaque (*Macaca radiata*); Lion-tailed macaque (*M. silenus*); Nilgiri langur (*Presbytis johnii*); Hanuman langur (*P. entellus*)

Values in parentheses indicate encounter rate per kilometre

TABLE 13
NUMBER OF ARBOREAL MAMMALS ENCOUNTERED AT DIFFERENT ALTITUDES (M)
IN INDIRA GANDHI WILDLIFE SANCTUARY

Species	<500	501-1000	1001-1500	>1500	Chi-square	p
Giant squirrel	-	47 (0.43)	32 (0.77)	3 (0.05)	50.1	.01
Grizzled squirrel	6 (0.18)	-	-	-	32.3	.01
Bonnet macaque	123 (3.78)	94 (0.87)	26 (0.62)	-	1016.2	.01
Lion-tailed macaque	-	87 (0.80)	6 (0.14)	-	110.5	.01
Nilgiri langur	-	358 (3.31)	132 (3.18)	19 (1.04)	82.8	.01
Hanuman langur	127 (3.91)	19 (0.18)	-	-	2048.4	.01
Total distance of Transects (km)	32.51	108.22	41.51	18.24		
Animal/km	7.87	5.59	4.72	1.21		

Values in parentheses indicate encounter rate per kilometre

An analysis was specifically attempted for the occurrence of elephants in the wet and dry ranges during wet (June-November) and dry (December-May) periods (Table 15). The data clearly indicated that the elephants occurred with a higher frequency in the wetter ranges of the west during the dry season and in the drier ranges of the east during the wet season. The reliability of the data was indicated by the overall

occurrence of elephants in 41.5 and 42.8 % plots in wet and dry season respectively.

Incidental encounters of some mammalian species

Small mammals and Nilgiri tahr: The data on our long term but incidental recordings of small mammals and Nilgiri tahr obtained through night drives and walks of known distance is presented in Table 16. The sighting frequency was converted to encounters per kilometre. Many small mammals were found only in some characteristic habitat types in the Sanctuary, but the data table in the end presents the overall encounter rates for the entire Sanctuary. Slender loris (*Loris tardigradus*) was seen only in the drier regions of the Sanctuary, with an overall encounter rate of 0.04 animals/km. Flying squirrel (*Petaurista petaurista*) and

TABLE 14
OCCURRENCE OF SIGNS OF MAMMALIAN SPECIES
IN PLOTS IN WET AND DRY RANGES
OF INDIRA GANDHI WILDLIFE SANCTUARY

Species	Wet ranges	Dry ranges	Chi-square	p
Prey species				
Gaur	60 (42.2)	8 (8.2)	32.7	.01
Sambar	64 (45.1)	35 (36.1)	1.9	NS
Muntjak	22 (15.5)	11 (11.3)	0.8	NS
Mouse deer	10 (5.6)	1 (1.0)	4.7	.05
Chital	3 (2.1)	13 (13.4)	11.8	.01
Pig	10 (7.0)	13 (13.4)	2.7	NS
Porcupine	8 (5.6)	10 (10.3)	1.8	NS
Signs/plot	177 (1.25)	91 (0.94)		
Predators				
Tiger	8 (5.6)	2 (2.1)	1.8	NS
Leopard	10 (7.0)	12 (12.4)	1.9	NS
Dhole	2 (1.4)	5 (5.1)	2.8	NS
Signs/plot	20 (0.14)	19 (0.19)		
Number of Plots	142	97		

Values in parentheses indicate occurrence of signs in per cent plots

TABLE 15
OCCURRENCE OF SIGNS OF ELEPHANTS
IN PLOTS IN WET AND DRY RANGES
ACROSS SEASONS IN INDIRA GANDHI
WILDLIFE SANCTUARY

Ranges	Wet season	Dry season	Chi-square	p
Wet	118 (35.6)	24 (58.3)	4.3	.05
Dry	58 (53.4)	39 (33.3)	3.8	.05
Overall	176 (41.5)	63 (42.8)	.003	NS

Values in parentheses indicate occurrence of signs in per cent plots

TABLE 16
NUMBER OF SOME SMALL MAMMALS ENCOUNTERED PER KILOMETRE IN DIFFERENT AREAS
IN INDIRA GANDHI WILDLIFE SANCTUARY

Area	Loris	Flying squirrel	Mouse deer	Nilgiri marten	Stripenecked mongoose	Brown palm civet	Small Indian civet	Common palm civet	Small cats	Distance covered (km)
Amaravathi-Chinnar	0.21	-	-	-	-	-	-	-	-	24
Contour Canal-Navamalai	0.12	-	0.05	-	-	-	0.02	0.11	0.01	186
Top Slip	0.25	0.07	-	-	-	-	-	0.05	-	12
Aliyar-Kadamparai Gate	0.05	-	-	-	-	-	-	0.27	-	120
Upper Aliyar-Vandal	-	-	0.003	-	-	-	0.01	0.01	0.003	324
Manampalli-Panathiar-K. gate-Waterfall	-	-	0.14	-	-	-	-	0.19	-	42
Andiparai-Iyerpadi-Urlikal	-	0.27	0.13	0.04	0.10	0.18	-	-	0.01	70
Puthuthotam	-	1.92	0.27	-	0.12	0.20	0.07	-	-	40
Overall	0.04	0.12	0.03	0.003	0.01	0.04	0.01	0.08	0.004	
Number of animals seen	37	99	28	3	12	13	10	67	4	818

Loris (*Loris tardigradus*); Flying squirrel (*Petaurista* sp.); Nilgiri marten (*Flavigula gwatkinsi*); Stripenecked mongoose (*Herpestes vitticollis*); Brown palm civet (*Paradoxurus jerdoni*); Small Indian civet (*Livingstonia indica*); Common palm civet (*Paradoxurus hermaphroditus*)

TABLE 17
OCCURRENCE OF SIGNS OF BIOTIC FACTORS IN TRANSECTS IN DIFFERENT RANGES
IN INDIRA GANDHI WILDLIFE SANCTUARY

Range	No. of transects	Grazing		Woodcutting	
		Moderate	Severe	Rare	Common
Valparai	9	1 (14.3)	1 (14.3)	5 (55.5)	1 (11.1)
Manampalli	6	2 (33.3)	0	4 (66.7)	1 (16.7)
Ulandy	7	0	0	1 (14.3)	0
Pollachi	3	1 (33.3)	2 (66.7)	2 (66.7)	0
Udumalpet	9	2 (22.2)	7 (77.8)	3 (33.3)	1 (11.1)
Amaravathi	3	0	3 (100)	0	2 (66.7)
Chi-square		4.29	23.35	8.95	7.63
p		NS	.01	NS	NS

Values in parentheses indicate occurrence of signs in percent plots

mouse deer were met with encounter rates of 0.12 and 0.03 animals/km respectively, with a considerably higher rate in the wetter forests. Nilgiri marten and striped-necked mongoose (*Herpestes vitticollis*) (0.003 and 0.01 animals/km respectively) were also found only in the wet regions. The distribution of different species of civets showed strong ecological correlates. In the lower altitude and relatively drier forests, common palm civet and small Indian civet were sympatric, the former being more common (Fig. 3). In the higher altitude and wetter regions, brown palm civet and small Indian civet were sympatric. The brown palm civet was more common in the forested regions, whereas the small Indian civet preferred relatively open areas such as tea estates.

Fig. 4 presents the information on the distribution of Nilgiri tahr in the Sanctuary (Appendix-III). The Nilgiri tahr was found mainly in the rocky terrain and hilltops from 500 m (3 HP on Aliyar-Valparai Road) to about 2,500 m (Akkamalai ridge) and occurred in both wet and dry regions. The presence of tahr could be classified into eight distinct populations in the Sanctuary. Populations I (8 animals), III (14 animals) and IV (indirect evidence of presence) appeared to be isolated in the Sanctuary, but it is possible that they are continuous with populations in Parambikulam Wildlife Sanctuary

in Kerala. These areas need further exploration. Populations VI (71 animals sighted at one time) and VIII (2 animals) were again isolated populations. Population VI at Pachchapalmalai appeared to be a biologically self-sustaining population, whereas Population VIII probably had only a few animals. Two populations, i.e. Population II (39 animals) and Population V (32 animals) were distributed over relatively large areas with probably low densities. A relatively high density (191 animals sighted at one time) was observed in Population VII (211 animals) in the Akkamalai-Grasshills region, which is continuous with Eravikulam Wildlife Sanctuary in Kerala, making this population contiguous with that in Kerala.

Mammals sighted in tea gardens: Many private tea gardens in the Valparai plateau still retain fragments of rainforest (Fig. 1) and also have areas under eucalyptus plantations. Although line transects and plots were not laid in these forests fragments during the present study all incidental encounters with wild mammals in the private estates and forests were recorded. The number of encounters with wild mammals was as follows: elephant herds (22), gaur herds (63), sambar (88), muntjac (176), mouse deer (16), wild pig (3), porcupine (3), bear (13), tiger (1), leopard (14), dhole packs (27), jackal (*Canis aureus*) (4), leopard cat (*Felis*

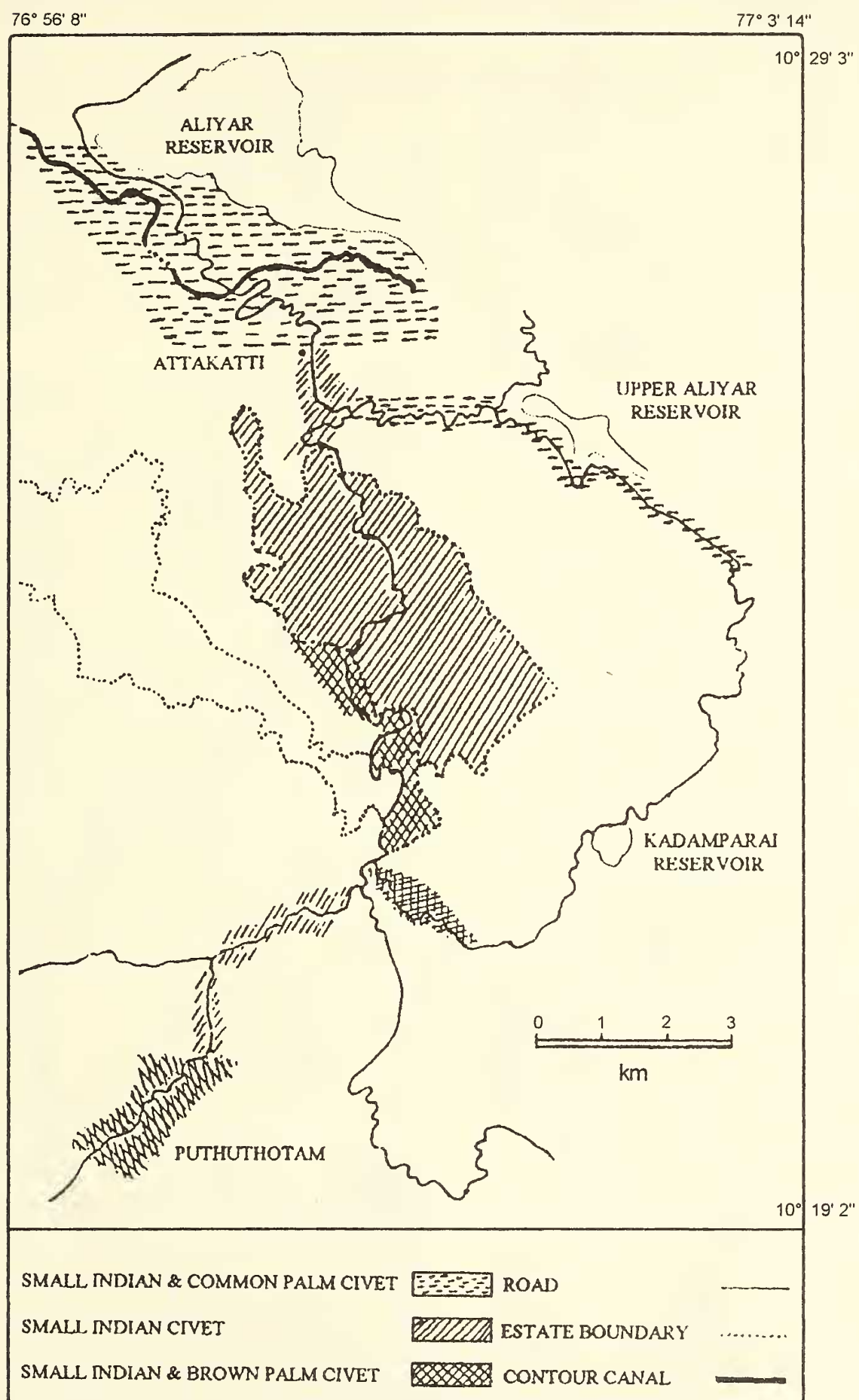


Fig. 3: Distribution of civets in Indira Gandhi Wildlife Sanctuary and private tea gardens around Aliyar-Valparai Road

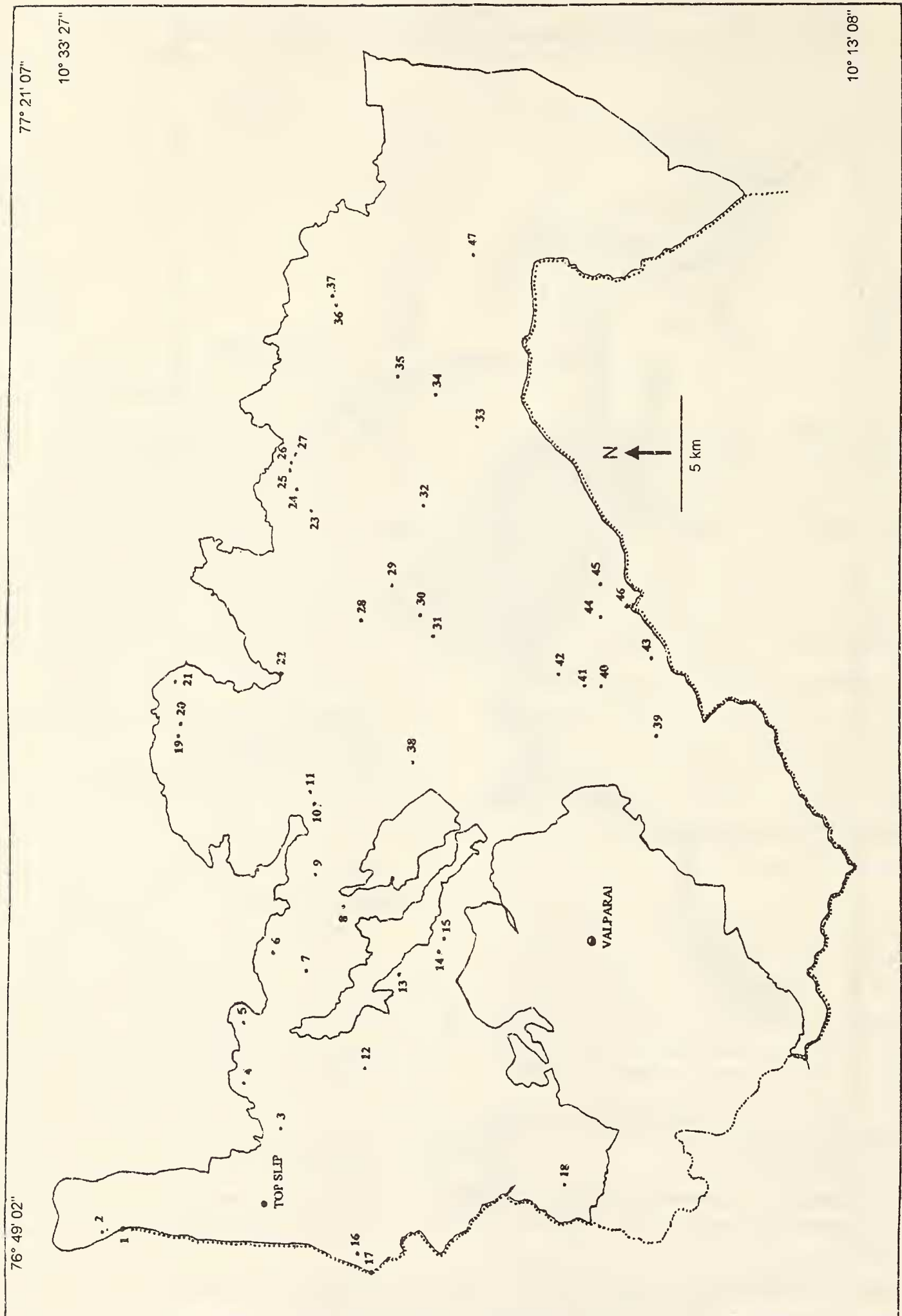


Fig. 4: Populations of Nilgiri Tahr in Indira Gandhi Wildlife Sanctuary (see Appendix-III for names of places)

bengalensis) (3), unidentified cat (1), striped-necked mongoose (23), brown palm civet (8) and small Indian civet (33). In addition, several fragments harbour resident populations of lion-tailed macaque, Nilgiri langur, Malabar giant squirrel and flying squirrels (*Petaurista* sp). The small and arboreal mammals are resident in the forest fragments used by the larger terrestrial animals to move between Manampalli/Shekalmudi and Akkamalai/Iyerpadi forests.

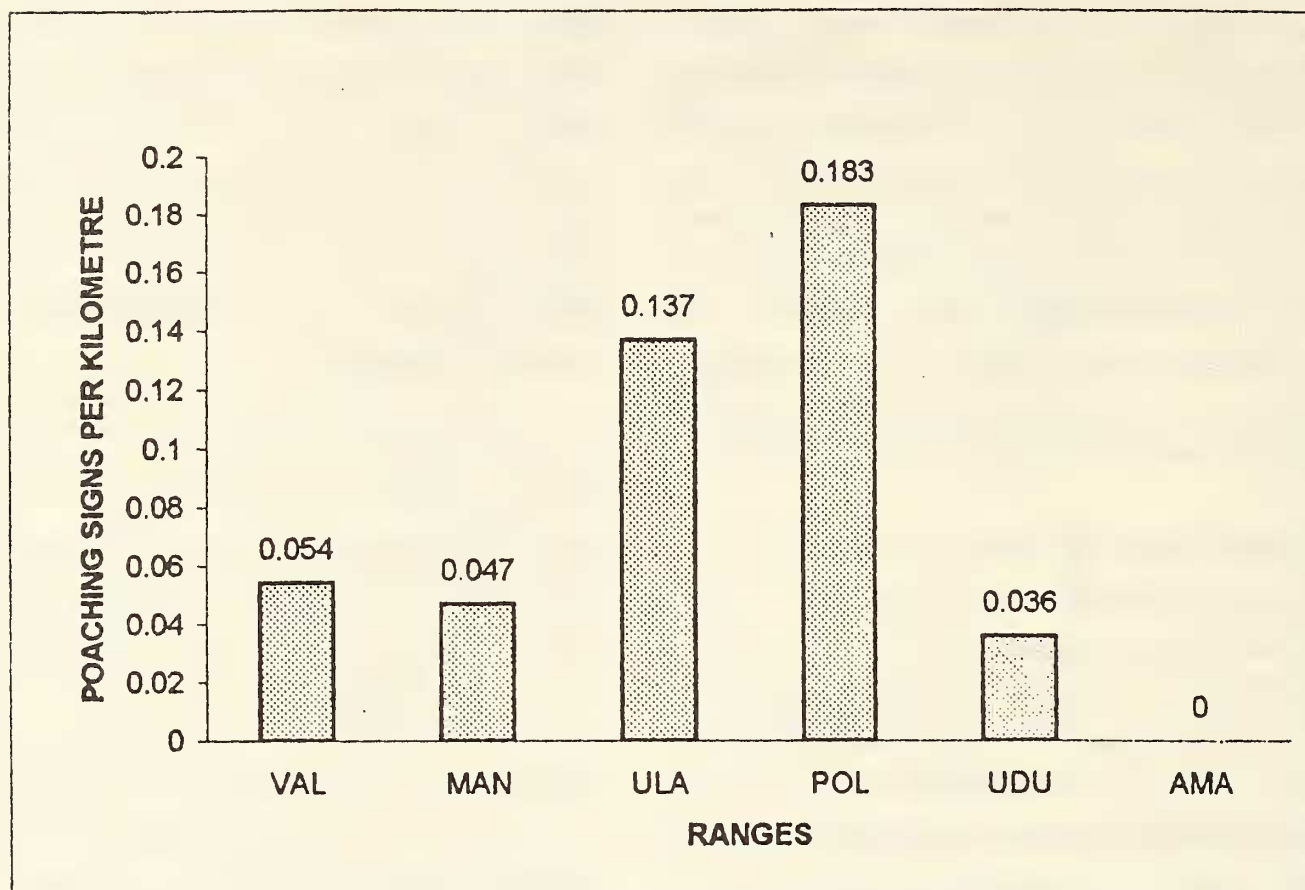
Biotic factors and barriers for dispersal

Biotic pressures on the Sanctuary: Table 17 presents data on grazing by the livestock and woodcutting by people in the Sanctuary. Statistically significant differences were observed for severe grazing in various forest ranges. High grazing pressure was observed in the drier ranges including Pollachi, Udumalpet and Amaravathi. Grazing by the livestock was not observed in Ulandy, and the pressure was not severe in Valparai and Manampalli ranges. Although woodcutting was more common in Amaravathi, the chi-square test did not show any significant difference among the various forest ranges. Fig. 5 presents the data on signs of poaching attempts per kilometre in different ranges. More snares and traps were found in Ulandy and Pollachi ranges as compared to other ranges. No such signs were found in Amaravathi range. Traps of different sizes made out of wooden stumps and bamboo were found during the study. Snares made out of plastic wires and wire mesh were also found. Most of these traps were placed in forest fringes along estates or village boundaries. The traps were also found near water holes and in the regularly used animal tracks. Over the years we observed occasional stealing of kills made by dhole and leopard in some tea estates bordering forest areas. Analysis was also carried out for the occurrence of all mammalian species in per cent plots with relation to biotic factors. With the exception of gaur, the distribution of no other species was found to be in any way

influenced by the biotic factors, the details of these analyses are not presented here. Gaur was found to occur in 41.3, 8.0 and 0 percent plots, in plots with no grazing, moderate grazing and severe grazing, respectively. A chi-square analysis ($\chi^2=39.5$; $df=2$; $p=0.01$) revealed the above frequencies of occurrence of gaur in plots to differ significantly.

Barriers for dispersal of mammals: The barriers (Fig. 6) for dispersal of mammals in Indira Gandhi Wildlife Sanctuary were both natural and man-made. The natural barriers were hills with steep slopes. Man-made barriers included tea estates, hydel projects, human settlements and various roads. The most prominent barrier was the road between Aliyar and Valparai. Not only is the traffic heavy on this road, but the terrain from Aliyar up to Iyerpadi forest makes the movement of animals between west and east difficult. South of Iyerpadi forest, the Valparai plateau area was cultivated for tea. The western and eastern sides of this road have become two separate regions with a small corridor between them at Iyerpadi and Andiparai forests. Aliyar, Upper Aliyar and Kadamparai system of reservoirs further separate the eastern and western ranges.

In the eastern parts of the Sanctuary, a large number of tribal settlements with domestic cattle were an obstruction to the free movement of mammals. As may be seen in Fig. 6, the tribal settlements in the eastern region were not only more numerous than in the western region, they were also clustered, most of them with their livestock were concentrated in the drier parts of the Sanctuary. Although the average number of households per settlement (about 23) was the same in the wet and the dry regions, the livestock averaged 3.9 animals per household in the dry region against 0.3 animals in the wet region. In addition, there were several colonies for the staff of the Tamil Nadu Electricity Board. The concentration of these colonies, movement of personnel, vehicles, and cattle was primarily in



(VAL - Valparai, MAN - Manampalli, ULA - Ulandy, POL - Pollachi, UDU - Udumalpet, AMA - Amaravathi)

Fig. 5: Poaching signs per kilometre in different ranges

the drier regions at Attakatti, Upper Aliyar, Navamalai, and Kadamparai. Such movement is much less at Manampalli Power House in the wetter region. Due to the presence of steep hills and relatively dry scrub forests, the availability of forage and space for movement for wild animals was restricted to a few narrow valleys and streambeds. Most of these areas were also utilized by locals and their livestock, creating human-animal conflicts. In the western region, the southern forests of Valparai range were totally cut off from the northern forests of Manampalli and Ulandy ranges due to tea gardens in the Valparai plateau. Sholaiyar and Parambikulam reservoirs have cut off the adjoining forest areas.

DISCUSSION

Methodological issues

In the present study, line transect method based on direct sightings, and plot method based on indirect evidence, were used to complement

each other. The results obtained through these two methods reflect upon the relative efficacy of these methods for one time survey of mammalian species. As far as vegetation types and distribution of mammals was concerned, the two methods brought out two different distribution patterns. On the basis of direct sightings, large herbivorous mammals appeared to have a higher frequency in drier forests. However, the plot method indicated higher occurrence, except for elephant and wild pig, of these species in rainforests. Likewise, the encounter rates of these species were higher at lower altitudes (with dry and open forests), but the indirect evidence from plot method showed an even distribution at different altitudes. It is, therefore, very clear that visibility, determined by the nature of vegetation, is a limiting factor in the direct sighting method. Direct sightings have proved to be efficient in determining abundance and density of wild animals, but perhaps only when one repeatedly walks on transects. We propose that for a quick

appraisal of mammalian distribution and relative abundance in a single survey, the plot method is more useful.

Habitat types, mammalian distribution and niche separation

The 958 sq. km area of Indira Gandhi Wildlife Sanctuary is characterized by a variety of habitat types. A unique feature of the Sanctuary is the presence of the Western Ghats ridges and plateaus receiving heavy monsoon, and the eastern slopes and plains in the rain shadow. These rainfall patterns have led to the growth of forests that include scrub jungles, deciduous forests, rainforests, shola and grasslands. These habitat types in turn support a variety of wild mammalian species that inhabit all or most habitat types, or are typical only to some habitat types. Some of the large herbivorous mammals such as elephant, gaur and sambar, that are more or less generalized feeders, occur in almost all habitats. Elephant, the most generalized feeder, even moves from wet ranges during the dry season to dry ranges during the wet season. On the other hand, typical niches such as scrub jungles of plains and rocky faces of mountains are occupied by chital and Nilgiri tahr respectively. The Nilgiri tahr populations described in this paper are similar to those described earlier (Mishra and Johnsingh 1998).

Similar ecological separation in closely related species can be seen in small mammals too. The common palm civet inhabiting dry forests of the lower altitudes is replaced by the brown palm civet in the wetter forests at higher altitudes. The small Indian civet also occurs at higher altitude, but is usually found in open areas such as tea gardens, and hence is separated from the forest dwelling brown palm civet.

The most remarkable case of niche separation was observed in arboreal mammals. The Malabar giant squirrel, occurring at a high frequency in many habitat types, is seen at a significantly lower frequency in the riparian

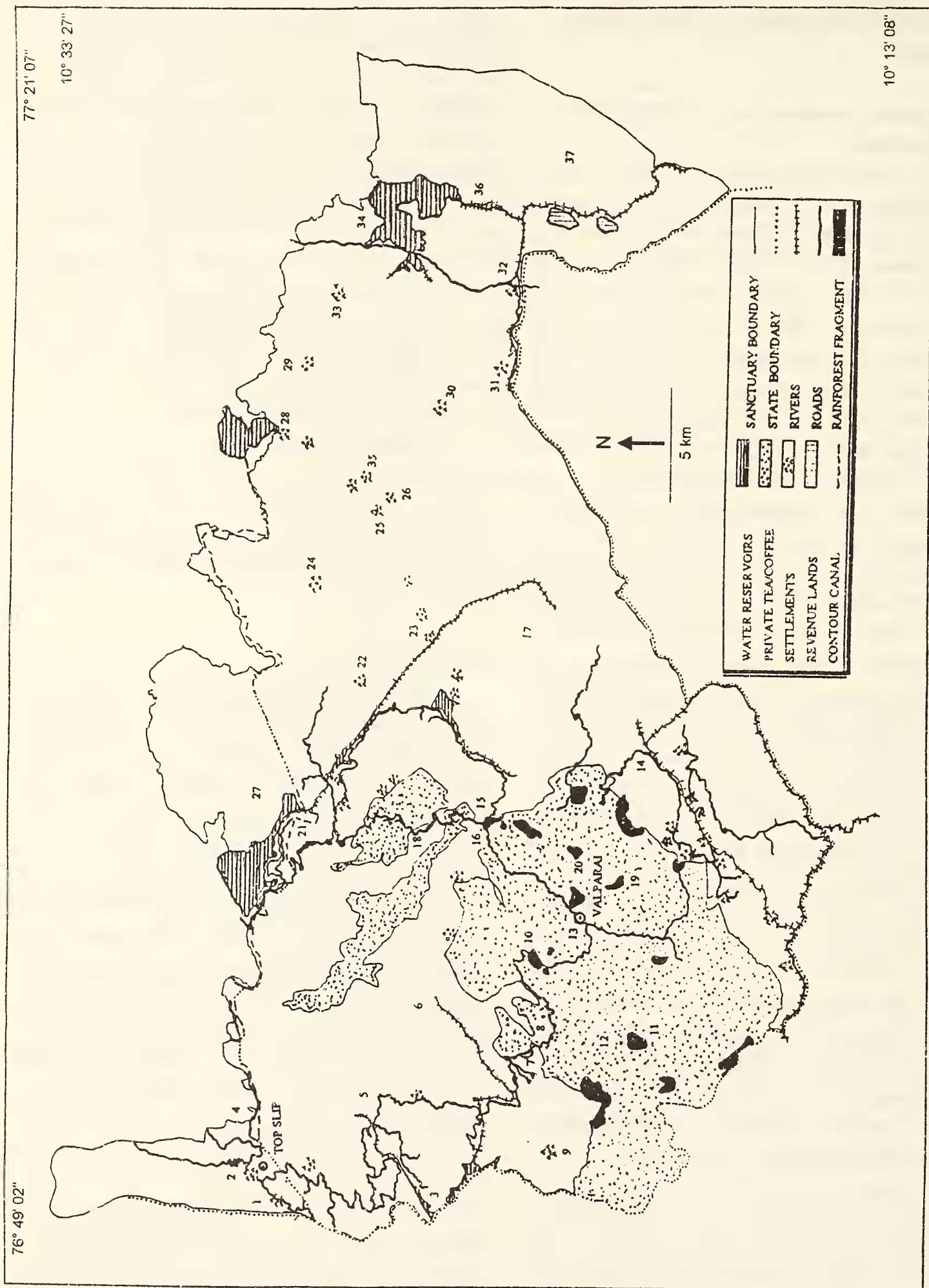
forest at <1,000 m. The riparian forests in the eastern part of the Sanctuary are occupied by the grizzled squirrel. In the rainforests at >1,000 m, lion-tailed macaque and Nilgiri langur are sympatric, but Nilgiri langur also inhabits moist deciduous forests. In the dry forests at lower altitudes, the riparian forest is primarily occupied by the Hanuman langur, while deciduous and scrub forests are inhabited by the bonnet macaque. Though not as clear cut as in other taxa, a tendency towards niche separation may also be observed in large carnivores. Tiger and gaur is more abundant in the western regions, whereas leopard, dhole and chital are more abundant in the eastern ranges.

A higher frequency of most terrestrial mammals was observed in 'monoculture' as compared to other habitat types. This may be due to the fact that animals use the patches of teak plantations to move between different habitat types.

Biotic factors

Although there are biotic pressures in the form of grazing, woodcutting and poaching, these factors did not appear to influence the distribution and relative abundance of most wild mammals. However, grazing by the livestock appears to have significantly affected the occurrence of gaur. The present data, and also our observations of several years, show that gaur is almost absent from the areas grazed by livestock. In the entire eastern parts of the Sanctuary, gaur occurs only on some steep slopes or in some valleys, which are not grazed upon by the livestock. This pattern can be seen in the Navamalai-Contour Canal region. Gaur is frequently seen south of contour canal where the livestock is prohibited, but in the entire area north of the canal, which is grazed by cows and buffaloes, it has never been observed though some habitat is suitable for gaur. Similarly, in the upper Aliyar-Kadamparai-Vandal region, and also around tribal settlements in the eastern parts,

Fig. 6: Natural and man-made barriers for animal dispersal in Indira Gandhi Wildlife Sanctuary



1. Karian Shola, 2. Top Slip, 3. Perambikulam, 4. Sarkarpathi, 5. Varagaliyar, 6. Ayangulam, 7. Manampalli P. House, 8. Urlikal, 9. Shekalumudi, 10. Varutparai, 11. Korangumudi, 12. Sholaiyar, 13. Valparai, 14. Cinnakallar, 15. Iyerpadi, 16. 36HP, 17. Akkamalai, 18. Andiparai, 19. Sirikundru, 20. Nadumalai, 21. Navamalai, 22. Mavidappu, 23. Karumutti, 24. Kulipatti, 25. Kurumalai, 26. Kottaiar, 27. Erumakandi, 28. Thirumurthy, 29. Isalthittu, 30. Attukudi, 31. Kodandur, 32. Chinnar Check Post, 33. Elumalaikovil, 34. Amaravathi, 35. Vandiar, 36. Thuvanam, 37. Varavandiodai

though a large area is relatively dry, it is still suitable for gaur in most places. The availability of natural fodder in these areas is evident from the fact that a large number of domestic animals graze here.

Management of wild mammals in Indira Gandhi Wildlife Sanctuary

The habitat types, distribution and relative abundance of mammals and the biotic pressures in Indira Gandhi Wildlife Sanctuary have implications for management.

Management in the wet western region:

The main feature of the western ranges is the fragmentation of rainforest, and the presence of forest fragments in tea estates. In a detailed study of forest fragmentation and its effect on arboreal and terrestrial small mammals, Kumar *et al.* (1998) stated that several parameters related to these fragments influence the presence of mammals in different ways. The size of the fragments influenced the occurrence of arboreal mammals with lion-tailed macaques as the most affected. The loss of canopy contiguity directly affected the presence of the Nilgiri langur. The distribution patterns of rodents were influenced such that the forest fragments smaller in size and frequented by humans have become dominated by the commensal species. Spiny dormouse has disappeared totally from small fragments. According to Kumar *et al.* (1998), more than the size, it was the quality of a fragment that determined the occurrence of mammalian species. This observation has far reaching implications for the management of forests and wildlife in the western ranges of Indira Gandhi Wildlife Sanctuary. As mentioned in the results, the Valparai plateau is frequently used by small and large mammals to move between Manampalli/Urlikal/Shekalmudi and Nirar/Cinnakallar/Akkamalai areas. During these movements, the animals make use of the remaining forest fragments for forage and as shelter. Some of these very crucial private forest

patches are at Varutparai, Puthuthotam, Sirikundru, Korangumudi, Nadumalai, and other smaller patches of vegetation along streams. The region being a plateau, the animals have probably historically used these areas for movement, and will continue to use them. It is, therefore, a must that these forest fragments, including monocultures of eucalyptus in some places, are paid special attention. Since these fragments also harbour arboreal mammals, special attention also must be paid to the type of vegetation around and inside these fragments. A plan can be developed to retain these fragments, improve the quality of vegetation and also to link them through stream corridors. This plan is workable and can be executed with the help of the management of tea estates, showing them that it is in their long-term interest if the private forest fragments are maintained and improved. If these fragments are removed or further degraded, man-animal conflict may only become severe, resulting in the loss of property and human lives due to the larger mammals.

Some rainforest areas such as Sankarankudi are underplanted with cardamom. Green and Minkowski (1977) stated that clearing the dense undergrowth vegetation destroys the intricate network of roots supplied by the smaller plants rendering the soil in cardamom fields more vulnerable to erosion. As the removed vegetation no longer contributes to leaf litter and soil humus, the moisture retention capability of soil is reduced. They further stated that when a cardamom field is abandoned, the early successional stages of the forest are inhibited, with a long-term effect on the regeneration process. The area under cardamom plantation, therefore, should be minimized, or the practice should be abandoned.

Management in the dry eastern region:

Although there are a few perennial water sources available in the form of rivers such as Kurumalaiar, Vandiar, Kottaiar, Chinnar and Tirumurthy and Amaravathi reservoirs, most of

the areas in the northeast and southeast of the Sanctuary are dry. The terrestrial mammals, during the dry months, are restricted to areas where water is available. Elephants move to the wet regions in the west during the dry season. However, the other small mammals probably do not have such seasonal migrations. The steep hills in many parts of the east are inaccessible to many mammalian species, especially the larger ones. Therefore, the valleys and streambeds of these hills are critical and must be left undisturbed for local movement of animals. In many places, settlements are placed right inside the most feasible and the only accessible places for animals. For example, the Attukudi settlement has cut off animal movement from Vandiar and Kottaiar towards Kodandur. Isalthittu settlement is another critical point for animals to move between Elumalaikovil and Guddar. Further, the human movement is most frequent between Tirumurthymalai-Kurumalai, Tirumurthymalai-Kottaiar-Attukudi-Kodandur-Chinnar Check Post, Kurumalai-Kulipatti, Poosakottam-Thalamedupatti, Kulipatti-Karumutti, Mavidappu-Upper Aliyar-Navarmalai, Chinnar 9th Checkpost-Elumalaikovil and Vandal-Kadamparai. Although gaur are found in areas grazed by livestock in other sanctuaries such as Mudumalai, in Indira Gandhi Wildlife Sanctuary, the presence of domestic cattle appears to reduce the presence of gaur. Locals informed us that gaur was present in some areas about 50 years back, but is absent now. Although it is not possible to stop the movement of people and livestock immediately, it should be minimized in most crucial areas such as streambeds and valleys. The grazing areas should be clearly demarcated for settlements such as Kurumalai, Kulipatti, Attukudi, and Thalmedupatti. Minimizing grazing may also help to reestablish gaur in many areas where it is now totally absent in spite of habitat suitability. A serious thought must also be given to the eucalyptus plantations raised during 1970s and 1980s in many parts of the

eastern ranges. These monoculture plantations could be removed, permitting the native species to regenerate. This would result in an increase in the forage areas for herbivores.

Overall management perspectives: A vision for the Sanctuary 50 years from now must be clearly chalked out. In order to manage these hills scientifically, Nilgiri tahr, elephant and lion-tailed macaque may be taken as flagship species. These species are endangered and represent the terrestrial and arboreal wildlife of these hills.

Tribal settlements should be relocated outside the Sanctuary. However, this is easier said than done. Therefore, a highly pragmatic scheme must be developed with attractive incentives for these people to move out of the forest. It is our observation that most of the younger generation of these tribes are willing to settle outside. This is an intricate social problem and a multi-pronged strategy should be developed with a long-term perspective in mind. For now, the tribes may be supplied with iron poles and raw material for construction of houses. This practice will ease the pressure for logs from the forest.

Periodic monitoring of wild mammals: Due to the limitations of time and other resources, the line transects as well as the plots were monitored only twice in some areas and once in most areas. Data collected in this manner does not provide the statistical rigour that is needed. It is, therefore, suggested that a few transects and plots must be laid out permanently and repeatedly monitored in different seasons. This activity should be differentiated from the annual census. Records on the sightings and movement of larger mammalian species must be regularly maintained by the staff. Weekly entries may be made in the register kept by each range officer. The data may also be computerized to facilitate analysis. Such information would be extremely useful in identification of habitat use patterns by mammals.

Road kills account for a fairly large number of herpetofauna and small mammals (Kumara *et al.* 2000b) in the Sanctuary. Vehicular traffic on the roads inside the Sanctuary must be restricted to the essential at night and in the wet season. There is no need to construct new roads inside the Sanctuary. However, if such a necessity arises, the rainforest areas must be totally avoided. Further, the use of vehicles even by officials should be minimized on three roads: Varagaliyar-Manampalli, Akkamalai-Grasshills and 36HP-Kadamparai Dam. These roads go through the most sensitive areas and should not be open to tourists. Coordination must be established with the managers of tea estates to jointly carry out some conservation activities such as education and to curb the stealing of kills inside the estates.

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APPENDIX-I
TRIBAL SETTLEMENTS WITH APPROXIMATE NUMBER OF HOUSEHOLDS AND LIVESTOCK
IN INDIRA GANDHI WILDLIFE SANCTUARY

Sl. No.	Name of settlement	Region	No. of households	Number of cattle
1.	Erumuparai	Wet	40+	Not seen
2.	Kolikamuthi	Wet	40+	Not seen
3.	Varagaliyar	Wet	30+	Not seen
4.	Kumati	Wet	20	Not seen
5.	Nedungundru	Wet	30+	40+
6.	Sankarankudi	Wet	20+	Not seen
7.	Sundaranakudi	Wet	15+	Not seen
8.	Kallarkudi	Wet	14	10+
9.	Cinchonakudi	Wet	15	10+
10.	Udumanparai	Wet	40	15+
11.	Palagankudi	Wet	40+	20+
12.	Kavarakkal	Wet	15+	10+
13.	Kadamparai	Wet	10	Not seen
14.	Vellumudi	Wet	15+	15+
15.	Ithakuli	Wet	10	Not seen
16.	Mavidappu	Dry	35+	200+
17.	Karumutti	Dry	20+	40+
18.	Kulipatti	Dry	30+	50+
19.	Karumalai	Dry	75	250+
20.	Chinnar (Pollachi)	Dry	20+	10+
21.	Jallimuthuparai	Dry	7	10+
22.	Vandal	Dry	50	200+
23.	Kottaiar	Dry	15	20
24.	Atumalaikudi	Dry	15	15+
25.	Kodandur	Dry	15+	300+
26.	Tirumurthy	Dry	20+	100+
27.	Isalthittu	Dry	30+	100+
28.	Poosakottamparai	Dry	10	Not known
29.	Talamedapatti	Dry	10	15+
30.	Selavuthu	Dry	10	25+
31.	Elumalaikovil	Dry	1	10+
32.	Karathupathi	Dry	15	100+
33.	Keelpunachi	Dry	20+	50+
34.	Contour canal	Dry	10+	15+
35.	Navamalai	Dry	15+	50+

APPENDIX-II
TRANSECT NUMBERS, PLACES OF TRANSECT AND DISTANCE OF EACH TRANSECT

Transect No.	Place	Distance (m)	Transect No.	Place	Distance (m)
1	Konalar - towards Vandal	7,000	20	Varagaliyar - Kadavasati	2,000
2	Konalar - Periyakulam	6,000	21	Varagaliyar - Perugundru	2,500
3	Konalar - Kerala border	4,500	22	Varagaliyar - Parambikulam	1,000
4	Waterfall - Iyerpadi	4,000	23	Top Slip - Kolambamalai	2,775
5	Akkamalai - Iyerpadi	5,000	24	Angalakurchi - Erumukundi	3,000
6	36HP - Kavarakal	2,500	25	Navamalai - towards Mavidappu	1,500
7	Waterfall - Upper Aliyar Dam	4,000	26	Contour canal - Shakthi Estate	1,700
8	Mavidappu - Feeder Tank	3,200	27	Tirumurthy Malai - Kurumalai	4,126
9	Attakatti - Andiparai	4,000	28	Kurumalai - Kulipatti	4,576
10	Nedugundru - Power House	4,600	29	Kurumalai - Kottaiar	3,500
11	Nedugundru - Panathiar	3,900	30	Kottaiar - Kodandur	3,000
12	Shekalmudi - Searchtop	4,140	31	Kurumalai - Papamparai	4,780
13	Nallamudi - Edumalaiar	2,500	32	Kurumalai - Guddar	4,226
14	Cinchona Settlement - Itiliar	3,500	33	Guddar - Tirumurthy Malai	4,466
15	Power House - Kumati	3,130	34	Elumalaikovil - Ponganaodai	2,400
16	Top Slip - towards Pandaravarai	3,200	35	Cinnar Chowki - Kodandur	2,500
17	Top Slip - Kathadimalai	2,000	36	Kootar - Thuvanam	4,781
18	Top Slip - Anaigunthi	2,000	37	Amaravathi Dam - Thuvanam	1,750
19	Top Slip - Umayamalai	1,200	38	Amaravathi - towards Kaladigatti	1,500

For locations, see Fig. 2

APPENDIX-III
DISTRIBUTION OF NILGIRI TAHR IN INDIRA GANDHI WILDLIFE SANCTUARY

Hill range	Altitude (m)	Status	Forest Range
Population I			
Panadaravarai (1)	1,200-1,300	8 [^]	Ulandy
Kataradi Malai (2)	"	Present	"
Population II			
Kolambu Malai (3)	500-1,733	6 [^]	Ulandy
Sottakkal Malai (4)	"	Present	"
Kombanpalli Malai (5)	"	5*	Pollachi
Periyasallakatti Malai (6)	"	Present	"
Pachcha Malai (7)	"	Present	"
Varaiyadu Malai (8)	"	5*	"
3 HP (9)	"	9*	"
Navamalai Feeder Tank (10)	"	2*	"
Bhutagundu (11)	"	Present	"
Perunkundru (12)	"	12*	Ulandy
Periyatalanar Malai (13)	"	Present	Valparai
Nadumkundru (14)	"	Present	"
Chinnatalanar Malai (15)	"	Present	"
Population III			
Pamban Malai (16)	1,000-1,150	14 [^]	Ulandy
Vengoli Malai (17)	"	Present	"

APPENDIX-III (contd.)

DISTRIBUTION OF NILGIRI TAHR IN INDIRA GANDHI WILDLIFE SANCTUARY

Hill range	Altitude (m)	Status	Forest Range
Population IV			
Palagan Malai (18)	1,014	Present	Manampalli
Population V			
Manjimedu (19)	870-2,212	15 [^]	Pollachi
Thadaganachi Malai (20)	"	5*	Pollachi
Karimedu (21)	"	Present	"
Sanda Malai (22)	"	Present	Udumalpet
Puttu Malai (23)	"	Present	"
Varaiyattutittu (24)	"	Present	"
Keda Malai (25)	"	Present	"
Raman Malai (26)	"	Present	"
Kanji Malai (27)	"	Present	"
Varasatti Malai (28)	"	Present	"
Ten Malai (29)	"	Present	"
Bahirava Malai (30)	"	4*	"
Kokkana Malai (31)	"	Present	Valparai
Pichchi Malai (32)	"	5*	Udumalpet
Attu Malai (33)	"	Present	"
Pambu Malai (34)	"	3*	"
Arasiamma Malai (35)	"	Present	"
Kota Malai (36)	"	Present	"
Rasi Malai (37)	"	Present	"
Population VI			
Pachchapal Malai (38)	1,730	71*	Valparai
Population VII			
Usi Malai (39)	2,150-2,513	Present	Valparai
Tanaka Malai (40)	"	191*	"
Akkamalai (41)	"	6*	"
Tangachi Malai (42)	"	Present	"
Kallar Malai (43)	"	6*	"
Kaludaisutti Malai (44)	"	Present	"
Sedayandi Malai (45)	"	Present	"
Podu Malai (46)	"	8*	"
Population VIII			
Eruma Malai (47)	744	2*	Amaravathi

[^] Indirect signs; * Seen; Present: - Information from local people
 Number in parentheses indicates location in Fig. 4

